Title

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Journal

Vaccine, 40(52)

ISSN

0264-410X

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Publication Date

2022-12-01

DOI

10.1016/j.vaccine.2022.09.024

Peer reviewed

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Vaccine 40 (2022) 7571–7578

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Strategies to increase the intention to get vaccinated against COVID-19: Findings from a nationally representative survey of US adults, October 2020 to October 2021

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ARTICLE INFO

Article history:
Received 20 June 2022
Received in revised form 1 September 2022
Accepted 4 September 2022
Available online 12 September 2022

ABSTRACT

Objectives: We examined COVID-19 vaccination status, intention, and hesitancy and the effects of five strategies to increase the willingness of unvaccinated adults (≥18 years) to get a COVID vaccine.
Methods: Online surveys were conducted between October 1–17, 2020 (*N* = 14,946), December 4–16, 2020 (*N* = 15,229), April 8–22, 2021 (*N* = 14,557), June 17-July 6, 2021 (*N* = 30,857), and September 3-October 4, 2021 (*N* = 33,088) with an internet-based, non-probability opt-in sample of U.S. adults matching demographic quotas. Respondents were asked about current COVID-19 vaccination status, intention and hesitancy to get vaccinated, and reasons for vaccine hesitancy. Unvaccinated respondents were assigned to treatment groups to test the effect of five strategies (endorsements, changing social restrictions, financial incentives, vaccine requirements for certain activities, and vaccine requirements for work). Chi-square tests of independence were performed to detect differences in the response distributions.
Results: Willingness to be vaccinated (defined as being vaccinated or planning to be) increased over time from 47.6 % in October 2020 to 81.1 % in October 2021. By October 2021, across most demographic groups, over 75 % of survey respondents had been or planned to be vaccinated. In terms of strategies: (1) endorsements had no positive effect, (2) relaxing the need for masks and social distancing increased Intention to Get Vaccinated (IGV) by 6.4 % ($p < 0.01$), (3) offering financial incentives increased the IGV between 12.3 and 18.9 % ($p < .001$), (4) vaccine requirements for attending sporting events or traveling increased IGV by 7.8 % and 9.1 %, respectively ($p = 0.02$), and vaccine requirement for work increased IGV by 35.4 %. The leading causes (not mutually exclusive) for hesitancy were concerns regarding vaccine safety (52.5 %) or side effects (51.6 %), trust in the government's motives (41.0 %), and concerns about vaccine effectiveness (37.6 %).
Conclusions: These findings suggest that multiple strategies may be effective and needed to increase COVID-19 vaccination among hesitant adults during the pandemic.

1. Introduction

The challenge of increasing COVID-19 vaccination is a worldwide issue. Many governments are experimenting with strategies to increase uptake, such as nudges and incentives. There is a precedent for using these strategies to improve population health [1,2].

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https://doi.org/10.1016/j.vaccine.2022.09.024
0264-410X/

For example, text-based reminders (an example of a nudge) are effective in increasing COVID vaccinations [3,4]. Some governments have opted to mandate vaccines and restrict the activities of unvaccinated individuals [5],while others have offered incentives such as free ice cream and beer in exchange for being vaccinated or held raffles or lotteries worth tens of thousands of dollars [6] (Some examples of this include Ohio's Vaccine lottery [7], New Jersey's shot and a beer [8], the Netherlands's free herring [9], a Thai town's cattle lottery [10], and Hong Kong's Tesla offer [11]). Financial incentives and vaccine mandates have been used in the past to increase vaccinations against other diseases, for example California's $50 VAX FOR THE WIN campaign [12,13].

This study examines changes in unvaccinated respondents' intention to get vaccinated (IGV) against COVID-19, reasons for initial vaccine hesitancy, and the effects of five strategies that may be used to increase vaccination intention among unvaccinated adults (ages 18 and older) in the United States. The first strategy explores the effect of vaccine endorsements by members of the scientific community, healthcare professionals, or celebrities on IGV [14,15]. The second assesses changes to the framing of the uptake message, with one approach highlighting a possible gain derived from being vaccinated (not having to social distance or wear a mask) and another highlighting these restrictions. The third tests the influence of cash payments on IGV. The fourth examines the effects of vaccination requirements to enter establishments, attend events, or travel. The last evaluates the effect of employers mandating vaccination for employees to return to on-site work. Factors leading to resistance to these strategies were also analyzed.

2. Methods

The UCLA COVID Health and Politics Project conducted five cross-sectional surveys among U.S. adults from October 1–17, 2020 (N = 14,946 individuals), December 4–16, 2020 (N = 15,229), April 8–22, 2021 (N = 14,557), June 17-July 6, 2021 (N = 30,857), and September 3-October 4, 2021 (N = 33,088) on an Internet-based, non-probability, opt-in sample provided by the market research firm, Lucid. Lucid supplies respondents covering all U.S. states from a pool of existing on-line sample providers. Once selected to participate, each respondent receives an email invitation from the provider with a link to our survey. Respondents read a description of the study and opt-in if they choose. A detailed description of the sampling procedures and assessments of the representativeness of the sample is available [16]. Samples were constructed to match a set of demographic quotas on age, gender, race, ethnicity, region, income, and education. The data were weighted based on the 2017 American Community Survey (ACS) of the U.S. Census Bureau to be representative of the U.S. adult population.[1] This project was approved by the UCLA Institutional Review Board (IRB #20–000786).

2.1. Socio-Demographics and vaccination status

Data were collected using demographic quotas and analyzed using post-stratification weights to ensure national representativeness (see Methods section above), thus demographics of respondents were similar across waves (**Supplement Table A1**). Sociodemographic items include age (18–39; 40–64; ≥65 years), gender (male/female), race/ethnicity (White, Black, Asian American and Pacific Islander (AAPI), other race, and Hispanic), underlying medical diagnoses (no diagnoses or one or more of the following: heart or cardiovascular disease, diabetes, chronic respiratory or lung disease, high blood pressure, cancer, or another major chronic condition), educational attainment (high school or less; some college; college degree or higher), and household income (<$30,000; $30,000–$54,999; $55,000–$89,999; $90,000–$149,999; ≥$150,000).

To assess whether self-reported vaccination rates varied by respondent characteristics, **Supplement Table A2** presents weighted Chi-square tests of independence testing whether vaccination status is independent of a specific respondent characteristic within a given survey wave (April, July, and October 2021). Respondents were considered vaccinated if they reported partial vaccination by receiving at least one dose of a COVID-19 vaccine. (See online supplement for question wording.).

2.2. Measures

Intention to get vaccinated: Unvaccinated respondents in all survey waves were asked about their intentions to get a COVID-19 vaccine. In surveys conducted before the vaccine was available (October and December 2020) respondents were asked about their intentions "once a vaccine was available." In surveys after December 2020, those vaccinated were separated from those who intended to get vaccinated but had not. Responses were analyzed by age, gender, race/ethnicity, and number of significant underlying medical diagnoses. (See Online Supplement for question wordings.) Those respondents reporting a definite or probable IGV (or who had tried to or were partially vaccinated with one dose) were classified as likely to become vaccinated.

Vaccine Hesitancy: In October 2021, all 10,298 unvaccinated respondents were asked why they had not been vaccinated against COVID-19. Using a list of 12 possibilities related to vaccine safety or effectiveness, respondents could check as many reasons as applied. Responses were analyzed by age, gender, and race/ethnicity.

Endorsements: All 14,946 respondents in the October 2020 survey were asked to consider a soon-to-be released-COVID-19 vaccine as being safe, effective, only having mild side effects, and being potentially endorsed by a messenger. Individuals were randomly assigned to five treatment groups in which they read that the vaccine had been endorsed by one of the following messenger(s): (1) scientific sources, (2) their health insurance company, (3) their pharmacy, (4) their physician, or (5) religious/spiritual leaders; or to a control group with no endorsement.[2] A follow-up to the first set of endorsers, conducted after the approval of the COVID-19 vaccine in April 2021, assigned 7,249 unvaccinated respondents to a modified list of endorsers that included celebrities such as NBA star LeBron James and Univision news anchor Jorge Ramos. After reading the prompt, respondents in the treatment group and the control group were asked how likely they were to get the vaccine. Effects of endorsements compare IGV in each treatment group to IGV in the control group.

Financial Incentives: All 7,249 unvaccinated respondents in the April 2021 wave were randomly assigned to one of three incentive options in exchange for getting vaccinated: either an amount of $25, $50, or $100. Respondents were asked to consider how the incentive would affect their IGV and could choose from the fol-

[1] Data were weighted based on age, sex, race, Hispanic ethnicity, household income, education, language spoken at home, U.S. or foreign-born, the four major census regions, and urban–rural mix of the respondent's zip code; and the following interactions: Hispanic ethnicity by language spoken at home, education by gender, gender by race, race by Hispanic origin, race by education, and Hispanic origin by education [https://www.census.gov/newsroom/press-kits/2018/acs-1year.html].

[2] In the October 2020 wave, a randomly selected half of the respondents saw a prompt that framed the vaccine as protecting the respondent while the other half of respondents received a prompt framing the vaccine as protecting the respondent and other people. This manipulation resulted in no differences in the effects of endorsements. Results from both arms are analyzed together. See Appendix 3 for additional information.

lowing three outcomes: more likely to get vaccinated, less likely to get vaccinated, or no effect on their plans to get a COVID-19 vaccine. Weighted difference of proportion tests were conducted to assess whether increasing financial incentives affect IGV.

Vaccine Intention and Mask Wearing/Social Distancing: All 7,249 unvaccinated respondents in the April wave were randomly assigned to one of three conditions. A question about the likelihood of being vaccinated was supplemented with one of the following qualifiers: (1) respondents would no longer have to wear a mask and social distance after vaccination; (2) respondents would still have to wear a mask and social distance after vaccination; or (3) a control condition that said nothing about mask wearing or social distancing. The effects of the messaging treatments compare the percent of individuals who answered that they definitely or probably would get the vaccine in the two treatment groups relative to the percent indicating this in the control group.

Vaccine Intention and Activity-Specific Participation: In the July 2021 wave, a randomly chosen subset of 5,144 unvaccinated individuals were randomly assigned to four groups, each asking about a different social activity (attending a concert, sporting event, restaurant, or taking a vacation). Within each group, respondents were randomly assigned to a treatment condition, where a COVID-19 vaccination was required to participate in the activity, or to a control condition where vaccination was not required to participate.[3] Respondents could answer that they would probably or definitely get the vaccine, probably or definitely not get the vaccine, would do something else instead of the activity in question, or would try to do the activity anyway without getting vaccinated. The effect of the vaccine requirement was estimated separately for each of the four activities by comparing the proportion of respondents who would probably or definitely get the vaccine when required to participate to the proportion who respond similarly in the condition where it is not required.

Vaccine Requirement for Employment: In the July 2021 wave (n = 5,091) and October 2021 wave (n = 4,373), all unvaccinated individuals who were employed and did not work entirely from home before COVID-19 were asked whether they would get the COVID-19 vaccine if their employer required they do so to return to work. Respondents could answer "Yes" or "No" and the percent responding "Yes" is reported.

2.3. Data analysis

All percentages were weighted to represent the U.S. adult population. Weighted difference-of-means tests and Chi-square tests of independence were performed to detect differences in the response distribution between groups and subgroups. These tests of independence used a Rao-Scott correction. Tests were considered statistically significant if p-values were < 0.05. All analyses were conducted in R version 3.6.1.

3. Results

3.1. Intention to get vaccinated and vaccination

Intention to get vaccinated (defined as a probable or definite intention to get the vaccine prior to it being available; or obtaining one or more doses after it was available) increased over time from 47.6 % in October 2020 to 81.1 % in October 2021 (Fig. 1 **and Supplement Table A3,** p < 0.001). Between April 2021 and July 2021, overall vaccination rates increased by 18.1 percentage points from 48.8 % to 66.9 % (p < 0.001). This increase was likely driven by individuals who had previously reported they intended to get the vaccine as shown by the 17.3 percent decrease (p < 0.001) in the percentage of individuals who intended to or had tried to get the vaccine during this same time period. In contrast, the percent of individuals indicating no intentions to get vaccinated, about 25 %, showed no change (p = 0.27). By October 2021, vaccination rates increased to 75.8 %, likely driven in part by the initial vaccine holdouts getting the vaccine: the percent of individuals with no intentions to get vaccinated fell by 7.6 percentage points from April to October 2021 (p < 0.001), see Supplement **Table A3**.Fig. 2..

Self-reported vaccination rates varied by respondent characteristics and across waves. In each of the 2021 waves (April, July, and October), unvaccinated individuals were more likely to be younger (p < 0.001), female (p < 0.001), less educated (p < 0.001), and have lower incomes (p < 0.001) compared to vaccinated individuals in the same wave (**See Supplement Table A2**).

3.2. Vaccine hesitancy

Between September and October 2021, 9.4 % of the respondents indicated they definitely would not get vaccinated for COVID-19 and an additional 9.6 % said they were unsure or probably would not get vaccinated (Table 1). Among all unvaccinated individuals who had not tried to get the vaccine, the leading causes for hesitancy were safety (concerns about side effects, 51.6 %, or that the vaccine is not safe, 52.5 %), trust (in the government's motives, 41.0 %, or the vaccine in general, 19.0 %), and effectiveness of the vaccine (37.6 %). Some concerns were more frequent among older unvaccinated individuals (trust in the government's motives (60.5 %), safety (60.1 %), and effectiveness (40.5 %) and females (trust in the government's motives, 42.4 %). White unvaccinated respondents trusted government less (46 %) than Blacks (27.5 %) or Hispanics (32.7 %) but had a higher belief in vaccine effectiveness (40.9 % in whites versus 36.3 % in Blacks or 26.0 % in Hispanics).

3.3. Endorsements

None of the scientific, medical, or celebrity endorsements of the vaccine increased people's intentions to get the vaccine. As shown in Table 2, the endorsement by news anchor Jorge Ramos decreased intentions on average (8.3 percentage points, p =.039). This effect does not retain significance after a Bonferroni correction for multiple testing of eight conditions is employed (results after correction not shown).

3.4. Financial incentives

Offering financial incentives significantly increased overall intention to get vaccinated for COVID-19 for each of the three financial incentives offered. For each of the three vaccine incentives, more respondents indicated that the incentive would make them "more likely" to get the vaccine than "less likely" (p < 0.001). Increasing levels of financial incentive brought greater gains in intention to get vaccinated, with a $100 incentive having a statistically discernable increase from $25 (6.6 additional percentage points) (Table 2).

3.5. Masking and social distancing

Not having to wear a mask or socially distance in public after being vaccinated for COVID-19 increased the IGV by 6.4 percentage points (p <.01) relative to not being told of this benefit, especially among men (10.4 points; p <.01) (Table 2 **and Supplement A4-**

[3] To anchor the results and eliminate heterogeneity derived from respondents' individual preferences to engage in the activity, each group-based vignette instructed respondents to consider the situation in light of the fact that a friend wanted to participate in the activity and the respondent wanted to take the friend to the activity as a birthday present (see online Supplement for exact wording).

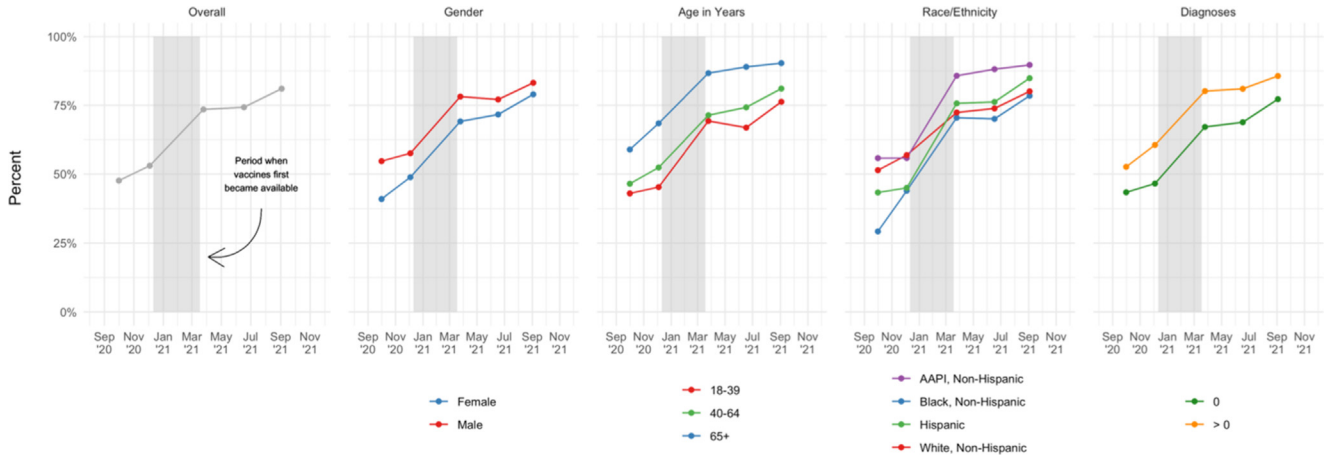

Fig. 1. Percent of Respondents Intending to Get Vaccinated or Already Vaccinated, October 2020-October 2021. *Note: In 2020, responses reflect intentions to get vaccinated. In 2021, responses include full or partial vaccination as well as intentions.*

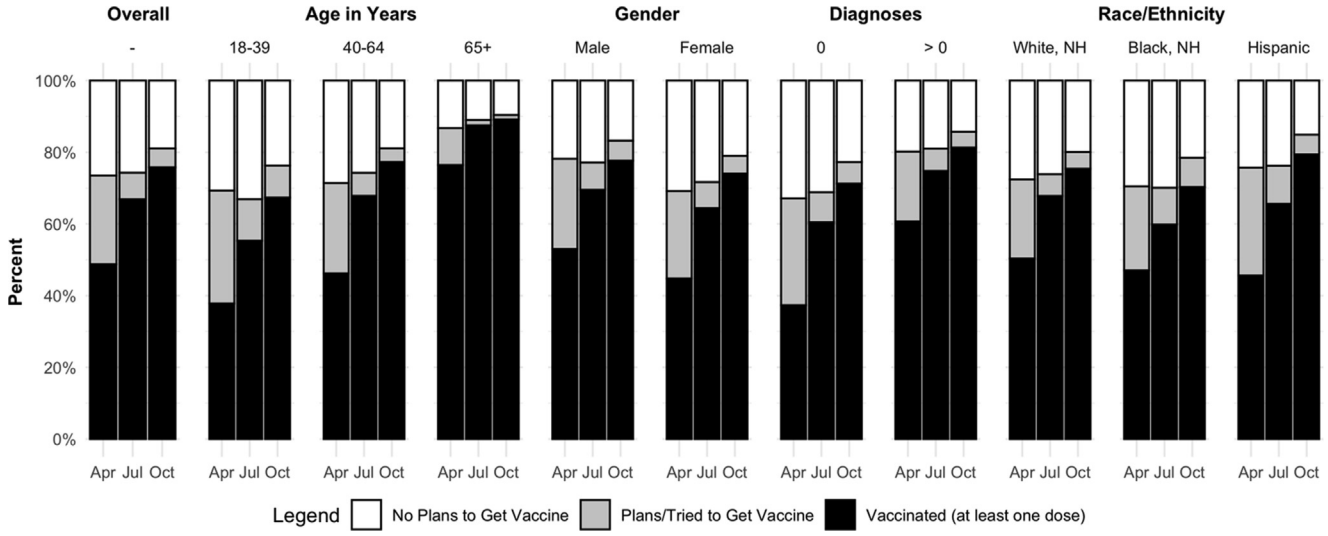

Fig. 2. Vaccination Status of Respondents, by demographic characteristics and survey wave, April through October 2021.

6). Conversely, being told that you would still have to wear a mask and socially distance after being vaccinated decreased respondent's intentions to vaccinate by 6.8 percentage points (p <.01) relative to not being told of this potential barrier, with women (-8.1; *p* <.01), non-Hispanic White respondents (-9.1; p <.001), and those aged 18–39 years (-9.9; p <.001) having the largest decreases (Table 2 **and Supplement A4-6**).

3.6. Vaccine requirements for Activity-Specific participation

Sizeable portions of the unvaccinated respondents indicated they would definitely or probably get a COVID-19 vaccine to participate in activities that take place in large groups – even if vaccination was not required. Specifically, respondents would get vaccinated to take a friend on a trip (23 %), or to a crowded concert (21 %), a sporting event (19 %), or to a favorite restaurant (16 %). For going to a sporting event and for going on travel, adding a COVID-19 vaccine requirement for participation significantly increased respondents' IGV when compared to what people indicated they would do without the vaccine requirement (control group). (See **Supplement Table A7** for levels of vaccine willingness by control and treatment assignment.).

Dining Out: Without a vaccine requirement, 16 % of unvaccinated people reported they would get a COVID-19 vaccine to take a friend to their favorite restaurant as a gift for their birthday. The vaccination requirement increased IGV among this group by an additional 5.5 percentage points on average (p = 0.11) (Table 2).

Concert: Roughly a fifth of the unvaccinated respondents said they would get a COVID-19 vaccine to take a friend to hear their favorite band give a concert even if no vaccine requirement were in place; adding the requirement did not increase uptake (21 % control vs 22 % mandate; p = 0.79) (Table 2).

Sporting Events: Without a requirement for vaccination, 19 % of unvaccinated people reported they would get a COVID-19 vaccine to take their friend to see their favorite sports team, with an additional 7.8 percent (p = 0.035) indicating they would get the vaccine if it was mandatory to attend the sporting event (Table 2). This difference was particularly large (12.8 point increase, p = 0.02) among people 18–39 years old relative to older individuals (See **Supplement Tables A4-6**).

Table 1
Incidence of Vaccine Hesitancy and Reasons for Not Getting Vaccine, September-October 2021.

	Overall	Age in Years			Gender		Race/Ethnicity		
	-	18–39	40–64	65+	Female	Male	White, Non-Hispanic	Black, Non-Hispanic	Hispanic
Vaccination Status									
Vaccinated	75.8	67.4	77.3	89.2	74.1	77.7	75.4	70.3	79.4
Tried to Get Vaccine	1.6	2.6	1.2	0.5	1.4	1.8	1.5	2	1.9
Likely To Be Vaccinated	3.6	6.3	2.6	0.7	3.5	3.8	3.2	6.1	3.6
Unsure or Unlikely To Be Vaccinated	9.6	13.1	8.8	4.2	10.5	8.6	9.6	11.5	9.3
Will Not Get Vaccinated	9.4	10.6	10.1	5.4	10.5	8.2	10.3	10	5.8
Unweighted Count	*33,088*	*13,703*	*13,683*	*5,702*	*16,654*	*16,434*	*21,987*	*3,995*	*4,707*
Reasons for Not Vaccinating (Among Those Who Had Not Tried To Get or Been Vaccinated)									
COVID-19 Not a Big Threat to My Health	20.2 (18.8,21.7)	19.5 (17.5,21.6)	19.6 (17.5,21.7)	27.1 (21.8,32.3) $p \leq .05$	17.1 (15.4,18.9)	24.1 (21.8,26.4) $p \leq .001$	23.5 (21.8,25.2)	11.8 (8.7,15.0)	13.7 (9.3,18.1) $p \leq .001$
Doctor Didn't Tell Me To	7.4 (6.5,8.3)	6.4 (5.1,7.7)	7.7 (6.3,9.1)	11.3 (7.5,15.1) $p \leq .05$	7.6 (6.4,8.8)	7.2 (5.7,8.6)	8.2 (7.1,9.3)	4.6 (2.6,6.5)	7 (3.7,10.4)
Don't Trust Government's Motives	41 (39.2,42.7)	34.3 (31.8,36.7)	45 (42.3,47.6)	60.5 (54.8,66.2) $p \leq .001$	42.4 (40.1,44.7)	39.2 (36.6,41.8) $p \leq .1$	46 (44.0,48.0)	27.5 (23.3,31.6)	32.7 (26.6,38.8) $p \leq .001$
Don't Trust Vaccines Generally	19 (17.6,20.4)	18.2 (16.2,20.2)	19.1 (17.0,21.2)	23.4 (18.5,28.4)	19.5 (17.6,21.4)	18.5 (16.4,20.6)	18.1 (16.5,19.6)	17.9 (14.7,21.2)	21.6 (16.2,27.0)
I am Already Immune	13.8 (12.6,15.0)	12.6 (10.9,14.3)	14.9 (13.0,16.8)	15.6 (11.4,19.7)	13.8 (12.1,15.4)	13.9 (12.0,15.7)	15.7 (14.2,17.1)	7 (4.8,9.1)	9.7 (5.9,13.6) $p \leq .001$
I am Concerned about Side Effects	51.6 (49.8,53.4)	46 (43.4,48.6)	56 (53.3,58.6)	63.9 (58.1,69.6) $p \leq .001$	56 (53.7,58.4)	46.2 (43.5,48.9) $p \leq .001$	54.9 (52.9,56.9)	43 (38.5,47.6)	43.2 (36.8,49.7) $p \leq .001$
Immune System Strong Enough	23.5 (22.0,25.0)	20.5 (18.4,22.5)	24.4 (22.1,26.8)	36.7 (31.1,42.4) $p \leq .001$	20.8 (18.9,22.7)	26.9 (24.5,29.3) $p \leq .001$	26.2 (24.4,28.0)	17.9 (14.4,21.4)	16.9 (12.1,21.8) $p \leq .001$
Let Other People Take Risk of Going First	14.9 (13.6,16.2)	17.8 (15.8,19.8)	12 (10.3,13.7)	11.7 (7.8,15.5) $p \leq .001$	13.9 (12.3,15.6)	16.1 (14.1,18.1) $p \leq .1$	15.5 (14.0,17.0)	12.6 (9.8,15.4)	15.2 (10.5,19.9) $p \leq .1$
Not Safe	52.5 (50.7,54.3)	51.7 (49.1,54.3)	51.8 (49.1,54.5)	60.1 (54.4,65.8) $p \leq .05$	53.2 (50.8,55.5)	51.7 (49.0,54.4)	54 (52.0,56.0)	50 (45.5,54.5)	51 (44.5,57.5)
Other Reason	7.8 (6.8,8.7)	9 (7.5,10.6)	7 (5.7,8.4)	3.8 (1.4,6.2) $p \leq .01$	8.2 (6.9,9.6)	7.2 (5.8,8.6)	7.3 (6.2,8.4)	11.2 (8.2,14.2)	7.4 (4.0,10.9)
Vaccine Not Effective	37.6 (35.9,39.3)	34.6 (32.2,37.1)	39.6 (37.0,42.2)	45.5 (39.6,51.3) $p \leq .001$	37.2 (35.0,39.5)	38.1 (35.5,40.7)	40.9 (38.9,42.8)	36.3 (31.8,40.7)	26 (20.3,31.7) $p \leq .001$
Will Use Masks or Other Precautions	25.4 (23.8,26.9)	24.2 (21.9,26.4)	26.8 (24.3,29.2)	25.8 (20.7,31.0)	29 (26.9,31.2)	20.9 (18.6,23.2) $p \leq .001$	23.2 (21.5,25.0)	30.5 (26.3,34.6)	25.6 (19.9,31.3) $p \leq .01$
Unweighted Count	*9,530*	*4,491*	*4,293*	*746*	*5,768*	*3,762*	*6,291*	*1,148*	*1,574*

Top Box: Incidence rates for vaccination and vaccine intentions combine answers to four questions: (1) number of doses received (2) attempts at vaccination (3) likelihood of future vaccination, and (4) whether unvaccinated respondents imagine ever being vaccinated. Columns sum to 100 percent.
Bottom Table: Respondents could check as many reasons as apply. Tests for significance are weighted Chi-square tests for within row independence across shaded categories of age, gender, and race/ethnicity (AAPI and other racial groups are not reported).

Travelling: The largest effect of a vaccine requirement was observed for traveling. Among unvaccinated respondents, 23 % said they would get a COVID-19 vaccine to travel with a friend even if vaccination was not required. An additional 9.1 percent ($p = 0.019$) indicated they would get vaccinated if it was required to travel (Table 2). The effects were particularly strong for women [12.1-point increase (20 % vs 32 %; $p = 0.015$)] and young people [18-point increase (24 % vs 42 %; $p = 0.001$)], See **Supplement Tables A4-6**.

3.7. Employer requirements

Among unvaccinated individuals who were employed and worked outside of the home before COVID-19, an employer requirement for COVID-19 vaccination would motivate 35.4 % of these individuals to vaccinate (Table 2) in July 2021 with a similar proportion (32.4 %) in October 2021. Larger effects were noted among Hispanic individuals on average (45.5 %, See **Supplement Tables A4-6**).

4. Discussion

Results from the UCLA COVID-19 Health Project surveys conducted between October 2020 and October 2021 indicate both incentives for vaccination and vaccine requirements increase intentions of unvaccinated individuals to receive a COVID-19 vaccine. Governments, employers, and the public health community all have a role to play in increasing Americans' intentions to vaccinate against COVID-19. Strategies found by our study to be beneficial, include offering financial incentives, imposing vaccine requirements for participation in activities such as to travel or attend a sporting event, requiring employees to be vaccinated for returning to work, or allowing individuals the freedom to shed masking and social distancing requirements if vaccinated. Incen-

Table 2
Effects of Strategies to Increase Vaccine Uptake.

Strategy	Wave		Effect
Endorsement	October '20	**Treatment vs Control (No endorsement)**	**PP Difference, CI**
		Scientific Sources (N = 1,820)	5 (-0.3, 10.3)
		Health Insurance (N = 1,887)	3.2 (-2.1, 8.4)
		Pharmacy (N = 1,890)	2.3 (-3.0, 7.7)
		Personal Physician (N = 1,921)	1.8 (-3.6, 7.1)
		Spiritual/Religious Leader (N = 1,834)	−4.5 (-9.9, 1.0)
Endorsement	April '21	**Treatment vs Control (No endorsement)**	**PP Difference, CI**
		Scientific Sources (N = 809)	−4.2 (-11.9, 3.4)
		LeBron James (N = 848)	−5.6 (-13.2, 2.1)
		Jorge Ramos (N = 800)	−8.3 (-16.2, −0.4) *
Financial Incentives	April '21	**Conditions (More v. Less likely)**	**PP Net Difference, CI**
		$25 (N = 2,488)	12.3 (8.1, 16.4) ***
		$50 (N = 2,336)	14.1 (9.6, 18.7) ***
		$100 (N = 2,400)	18.9 (14.4, 23.3) ***
Masks and Social Distancing	April '21	**Treatment vs Control (No mention)**	**PP Difference, CI**
		Masks and Social Distancing (N = 2,428)	−6.8 (-11.4, −2.3)**
		No Masks and Social Distancing (N = 2,314)	6.4 (1.9, 10.9)**
Vaccine Requirements	July '21	**Treatment (Requirement vs Not)**	**PP Difference, CI**
		Restaurant (N = 1,323)	5.5 (-1.2, 12.2)
		Band (N = 1,270)	0.9 (-6.1, 8.0)
		Team Sport (N = 1,234)	7.8 (0.5, 15.0)*
		Travel on a Trip (N = 1,317)	9.1 (1.5, 16.7)*
Employment Vaccine Mandate		**Question Responses**	**P, CI**
	July '21	Would Vaccinate to Return (N = 1,797)	35.4 (33.4,37.3)
		Would Not Vaccinate to Return (N = 3,294)	64.6 (62.7,66.6)
Employment Vaccine Mandate	October'21	**Question Responses**	**P, CI**
		Would Vaccinate to Return (N = 1,460)	32.4 % (30.2,34.6)
		Would Not Vaccinate to Return (N = 2,913)	67.6 % (65.4,69.8)

Note: P-values $\leq$ 0.05 *, 0.01 **, and 0.001 *** are from weighted difference-of-means tests across conditions within each interrogation. PP is percentage point, P is percent, CI is confidence interval.

tives including both monetrary payments and increased freedoms (travel, easing of masking and social distancing) were found to be effective in this study in significantly increased IGV, while endorsements by medical professionals and celebrities did not. Major barriers to vaccination include issues of safety, trust, and concerns about vaccine effectiveness, which do not seem to be allayed by assurances from notable elite endorsers at least during the time period studied, but may be overcome for some people if a vaccine comes with tangible benefits beyond inoculation.

The results of our study echo those of Kluver et al. [17] where messaging experiments performed online for 20,500 respondents in Germany showed that both providing freedoms (restoring liberties only to people who are vaccinated) and financial remuneration increased vaccination uptake two to three percentage points overall and five percentage points among the undecided. Financial incentives have been shown to be effective in increasing vaccination rates [12,13], as well as in other preventive behaviors such as weight loss [18,19] and smoking cessation [20]. As demonstrated by our results, the effect of financial incentives of $25, $50, and $100 increased with the dollar amount of the incentive [21,22]. However, the literature around financial incentives for COVID-19 vaccination is mixed [23]. Two studies showed no effect of monetary incentives ranging from €25-200 and the other from $10-$100 [24,25]. In another small U.S. study, compensations of at least $100 increased vaccine intentions compared to when no compensation was offered, but low levels of compensation ($20) reduced vaccine intentions [26].

A recent study of 4,000 individuals examined the combination of informing people that vaccination is required for international travel in conjunction with the fact that 2/3 of Americans support requiring proof of vaccination for travel, showing the combination to be very effective (1.6–2.2 times greater than either nudge alone) [27]. This is consistent with our results showing that an activity restriction related to travel was an effective strategy. Our study is unique in that the requirement for vaccination for travel had an effect in unvaccinated individuals even months after vaccination was widely available.

The current debate is whether universities, schools, and employers should mandate vaccination, especially in healthcare settings [28–31]. In healthcare settings, a COVID-19 vaccination mandate would follow similar requirements for the flu vaccine in healthcare personnel shown to be effective in systematic reviews [32]. In a study of over 2500 adults, only a minority of the population felt employer mandates for vaccination was appropriate [33]. Our results are unique in that the sample population was focused on unvaccinated adults working on-site at their job. A strategy of workplace COVID-19 vaccination requirements might convert 32.4 % of unvaccinated workers (4 % of the overall population) that were resistant, but a majority of these individuals seemed more inclined to quit their jobs rather than be vaccinated. This is similar to previous data from flu vaccine mandates, which showed that almost 31.7 % of individuals felt the mandate was an infringement of their autonomy, and almost 4 % would seek employment elsewhere [34].

The findings in this report are subject to several limitations. First, we used a nonprobability, quota-based sample, potentially increasing bias and limiting generalizability. The large sample size, however, lends confidence to the findings. Second, the surveys were administered online in English, which may have excluded participation by U.S. residents without Internet access and those with limited English or reading proficiency. Third, our data are cross-sectional, which limits our ability to talk about the heterogeneous effects of respondents' characteristics, attitudes, or beliefs over time. In future studies it would be beneficial to look within subsets of respondents for heterogeneous effects (in terms of conditional average effects) of our treatments by repeating the experiments over multiple waves. Fourth, the percentage of people who reported at least one dose in Oct 2021 in our survey was higher

(81 %) that what was nationally reported (67 %), which need to be considered for generalizability but not change the intervention effects reported in our study Finally, the data are based on self-reports and are subject to social desirability biases.

Results of this study indicate that for the significant portion of eligible adults who remain unvaccinated against COVID-19, vaccine mandates, financial incentives, and allowing vaccinated people to return to normal behaviors may overcome some self-reported hesitancy and increase self-reported intentions to vaccinate. In general findings studied serially over the course of the year-long study tended to remain similar even as the pandemic changed rapidly and profoundly, suggesting that these findings will persist into the endemic phase of the pandemic. Lessons learned about vaccination during the pandemic might be tested in other areas of health prevention such as cancer screening. These findings suggest that along with the public health community, business leaders and political decision makers are critical partners in the effort to increase adult vaccination rates during the pandemic.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

This study was supported by (a) the UCLA Marvin Hoffenberg Chair Fund, (b) Neria and Manizheh Yomtoubian Endowed Chair Fund, (c) UCLA David Geffen School of Medicine – Eli and Edythe Broad Center of Regenerative Medicine and Stem Cell Research Award Program to the UCLA Center for SMART Health, (d) Patient-Centered Outcomes Research Institute COVID Enhancement, "WISDOM in the age of COVID, (e) NIH/NCATS grant #UL1TR001881, and (f) A contract from the CDC National Institute of Occupational Safety and Health.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2022.09.024.

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